

A black and white photograph showing a pilot's perspective from the cockpit. The pilot's hands are on the yoke, and the instrument panel is visible. In the background, another aircraft is flying in the sky.

# Collision Avoidance

## Strategies and Tactics

Collision avoidance, in the air and on the ground, is one of the most basic responsibilities of a pilot operating an aircraft in VFR conditions.

### Maintaining Separation

Despite the improvements in general aviation's safety record in recent years, the incidence of midair collisions (MACs) shows no corresponding decline. MACs continue to occur about 16 to 18 times a year on average, often resulting in multiple fatalities. On the ground, reported runway incursions, or "surface deviations," which also carry the threat of devastating collisions, have risen as well, increasing far faster than the number of flight operations.

Collision avoidance, in the air and on the ground, is one of the most basic responsibilities of a pilot operating an aircraft in VFR conditions. During primary training, pilots are taught to keep their eyes outside the cockpit and look for conflicting traffic. But little formal instruction is given on the best ways to visually identify potential collision threats – or in procedures that can lessen their risk of occurring. Make the strategies and tactics in this *Safety Advisor* part of your standard procedures to keep the skies safer for you, and for those you share it with.

### History of MACs

Many of the rules and procedures that apply to flight in controlled airspace are the legacy of MACs. In 1956, a DC-7 and a Lockheed Constellation collided over the Grand Canyon in VFR conditions. All 128 people aboard the two aircraft lost their lives. Efforts to enhance air safety in the aftermath of the accident are behind the foundation of today's Air Traffic Control system. A 1978 collision involving a B-727 and a Cessna 172 over San Diego, both under radar control, caused the deaths of 144 people, and resulted in tighter restrictions on flights in heavily trafficked areas. And

# Pilots need to know how to look and what to look for.



It is the pilot's responsibility to "see and avoid" other traffic.

after the 1986 collision of a DC-9 and a single-engine Piper over Cerritos, California, that claimed the lives of 82 people in the aircraft and 15 on the ground, Congress passed the Airport and Airway Safety Expansion Act, which requires all civil aviation air carrier aircraft to be equipped with TCAS, or Traffic Alert and Collision Avoidance Systems.

No MACs involving an air carrier aircraft have occurred in over a decade, thanks in part to TCAS equipment. But the possibility of such an accident occurring still exists, and a midair collision involving a commercial transport aircraft and a general aviation aircraft would create pressure to enact further regulations that could ultimately have a detrimental impact on the flexibility and convenience of aviation for all. Therefore, every general aviation pilot has a responsibility to avoid MACs not only for their own safety, but for the safety of everyone flying.

## See and Avoid

The rules for maintaining separation from other aircraft in VFR conditions are spelled out in FAR 91.113: "When weather conditions permit, regardless of whether an operation is conducted under instrument flight rules or visual flight rules, vigilance shall be maintained by each person operating an aircraft so as to see and avoid other aircraft." "See and avoid" is the common terminology for this method of collision avoidance. But behind this principle are tactics and strategies every pilot must be familiar

with to minimize the potential for colliding with another aircraft.

It is instructive that the probable cause of the 1956 MAC over the Grand Canyon as determined by the NTSB could be said to be true of almost any midair collision today: "The pilots did not see each other in time to avoid the collision. Evidence suggests that it resulted from any one or a combination of the following factors: intervening clouds, visual limitations due to cockpit visibility, preoccupation with normal cockpit duties, preoccupation with matters unrelated to cockpit duties...(and) physiological limits to human vision reducing the time and opportunity to see and avoid the other aircraft."

The most important tool pilots have to "see and avoid" other aircraft is their vision. But simply looking out of the cockpit isn't enough. Pilots need to know how to look and what to look for. That requires understanding the limitations of human vision and ways to compensate for its deficiencies.

## The Physiology of Vision

A safe, conscientious pilot wouldn't take off as PIC in an airplane without knowing its performance limitations and how to operate the equipment aboard. Yet the majority of pilots routinely fly without knowing the limitations and operating rules for the most important collision avoidance equipment in the plane – their eyes. Eighty percent of the information we absorb in everyday life is obtained through our eyes. But using this input to see and avoid

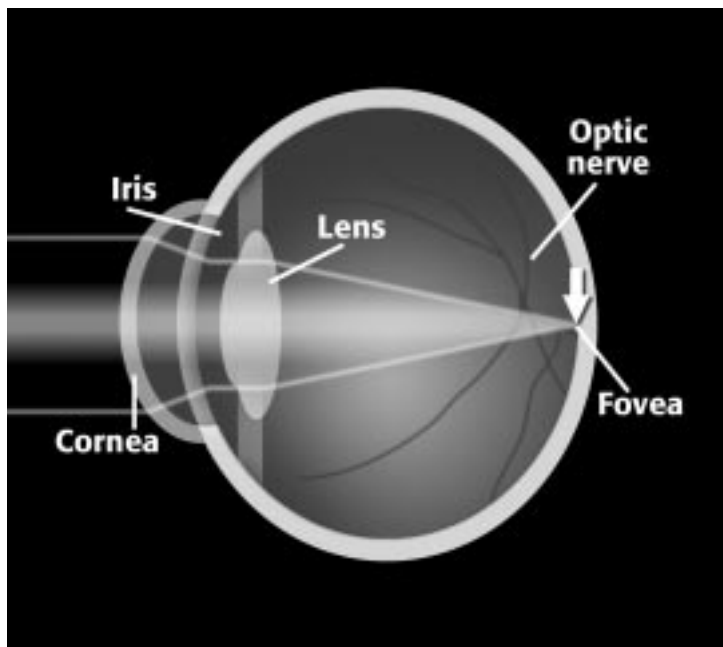


Figure 1.

other aircraft, that is, to develop a good scanning technique, requires knowledge of how vision works.

### The Foveal Field

The central part of the retina, where vision is most acute, is called the fovea (see figure 1). But this is a very small part of vision, comprising just one degree of horizontal and vertical vision. As a demonstration, this area of focus is the equivalent of a quarter seen from one eye at a distance of four and a half feet. Anything outside this small area will not be seen in detail. Outside of a 10 degree cone concentric to the foveal cone, visual acuity is only 10 percent of that of the foveal field of vision. In practical terms, a plane that was visible in the foveal field from 5,000 feet away would only be visible at 500 feet or less if it was more than five degrees on either side of this core vision. This is why scanning is so important – but more about that later.

### Focus

Focus is essential to vision. Unless the eyes are properly focused, an object can be right in front of a pilot yet remain unseen. In order to spot aircraft at a distance, the eyes must be focused for distant vision. Yet the eyes will relax to an intermediate focal distance somewhere just in front of the propeller in 60 to 80 seconds without something distant to focus on. To counteract this tendency, known as “empty field myopia”, the eyes must be periodically refocused on

the farthest object within sight – a cloud on the horizon, another aircraft at a distance, or a point on the ground. Such refocusing needs to be incorporated in a pilot’s scan technique.

### Atmospheric Conditions

Atmospheric conditions can also impact the eyes’ ability to discern collision threats. Haze, flight over open water, or an obscured horizon can make it difficult to see distant objects, and therefore complicate the ability to refocus vision to see targets at a distance. This problem can be overcome by focusing on the farthest point visible; even the wing tip will do. In times of poor visibility, this form of refocusing should be repeated every minute or so. The same phenomenon can occur at high altitudes or over a haze or cloud layer on days with a high overcast.

The position of the sun must also be considered. When low on the horizon, it makes any traffic between the observer and the sun very difficult to see. Thus, operating in these conditions requires extra vigilance, because, for all practical purposes, traffic conflicts may be visible from only one aircraft.

### Optical Illusions

In addition to miscues caused by atmospheric conditions, our eyes can also play tricks on us all by themselves. “Optical illusions,” as they’re commonly called, can affect what we see in flight. For example, an aircraft at a slightly lower altitude coming toward you may look like it’s above you and appear to descend as it comes closer. Night brings on its own challenges for vision, such as the decreased ability to



Haze and fog can impact the eyes’ ability to discern collision threats.

judge distance above the ground while on visual approach to a runway. Fortunately, spotting aircraft isn't usually one of these challenges; a properly illuminated aircraft in flight is much easier to see at night than an aircraft operating in daylight hours. The exception to this rule is identifying aircraft below you that blend in with ground clutter. This can be a problem day or night. Less than two percent of MACs occur after sundown. Pilots need to be aware of these optical illusions in order to resist reacting to erroneous visual cues.

### **Environmental Factors**

The eye itself can have its capabilities reduced by environmental and physical factors. Irritants in the air, fatigue, age, residual alcohol in the bloodstream, and lower oxygen levels can all impact the ability of the eye to perform optimally. Some systemic diseases can also compromise the ability to see. Pilots need to understand not only general limitations of human vision, but any individual physiological factors that might compromise their ability to see and avoid other aircraft.

### **Aircraft Design Considerations**

The design of the aircraft itself can also contribute to reduced visibility. Windshield distortion, placement of window and windshield posts, and other structural elements can affect what a pilot sees. The brain requires input from both eyes, that is, binocular vision, to accurately interpret the visual cues it receives. If the vision of one eye is blocked by a windshield post or other obstruction, the brain may not be able to see the object even if the other eye does. The NTSB has concluded this could be a causal factor in some in-flight collisions. A high glare shield can also block vision, and this is especially problematic during climbout.

No matter how good the visibility from the cockpit, all aircraft have blind spots. The major difference among various makes and models is the wing position. High-wing aircraft have reduced visibility of aircraft above them, and can have their view of traffic blocked when making turns in the pattern as the wing is lowered in the direction of the turn. Low-wing aircraft have a large blind spot beneath them that may obscure conflicting traffic when descending into the pattern or while on final approach. Pilots must



The position of each aircraft's wings creates blind spots that a pilot must be aware of when scanning for traffic.

recognize and compensate for the visual limitations of whatever aircraft they are flying. This includes raising a wing to check for traffic before making a turn in a high-wing airplane, and making shallow S-turns when climbing or descending in any aircraft.

### **When and Where**

Knowing when and where MACs are most likely to occur can help you maintain optimum vigilance in high-risk situations, by enabling you to tailor "see and avoid" strategies to any given situation. Most MACs occur in daylight and in VFR conditions – the times of best visibility. They can also be correlated to traffic levels: Most occur between 10 a.m. and 5 p.m. on weekends during the warmer months; in other words, times when most traffic is in the air. Most MACs also occur

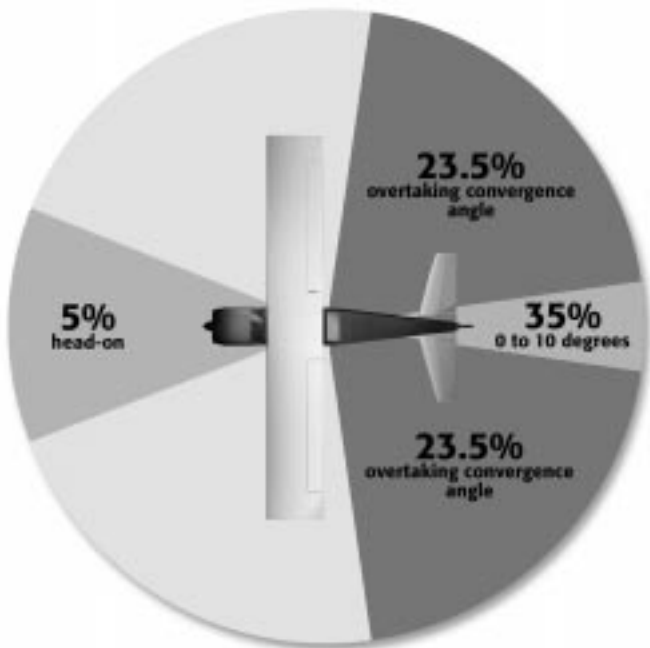


Figure 2. Note: Percentages are based on a study of 105 MACs. Some of the angles were unreported.

within five miles of an airport. About three-quarters (77 percent) occurred at or below 3,000 feet above ground level. And half (49 percent) occurred at or below 500 feet. These last three statistics illustrate an important fact: Most midairs occur in the traffic pattern, with almost half occurring on final approach. (En route, most collisions occur within 25 miles of an airport and at or below 8,000 feet.)

The closing speed at which the aircraft collide is typically relatively slow because MACs are rarely head-on. Collisions usually involve two aircraft going in the same general direction. Most such accidents result from a faster aircraft overtaking and hitting a slower moving airplane. Studies of MACs have found that 82 percent were at overtaking convergence angles. About a third (35 percent) were from zero to ten degrees, that is, almost straight from behind. Only five percent were from a head-on angle (see figure 2).

### Pilot Experience

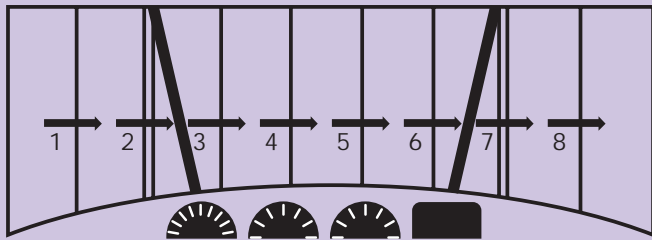
Most MACs involve low-time pilots. The greatest percentage occurs within the first 100 hours of flight and the overwhelming majority occur in the first 1,000 hours of flight time. But MACs can and do involve pilots of all skill and experience levels. The complacency that can come with thousands of hours of uneventful flying can lead to one lapse that ends in tragedy, with two aircraft attempting to occupy the same airspace at the same time.

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Paradoxically, though two sets of eyes are supposed to be better than one, flight training missions are among the most dangerous from a collision perspective. Flight instructors comprise less than 10 percent of the pilot population, yet a flight instructor was aboard one of the aircraft in more than one quarter of MACs (28.8 percent). The reason for this statistical anomaly is that flight instructors spend much of their time operating near airports, the most hazardous environment for MACs, and their attention is often focused on teaching, rather than scanning for traffic. And during instrument flight training, the student's, and instructor's, vision to the student's side is often restricted by a hood or goggles, and the instructor's attention may be diverted by the needs of training.

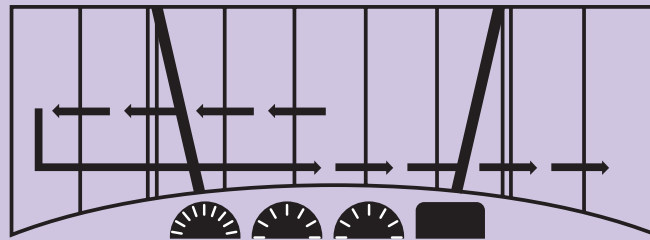
### The Scan

The "scan" is the technique used for harnessing our vision to the needs of collision avoidance. However, the term may be a misnomer, as "scan" implies a sweep of the eyes, while a proper scan for conflicting traffic is actually a sequence of intense, fixated observations. The eyes need one to two seconds for accommodation before they can focus; a continuous



#### Side-to-side scanning method.

Start at the left of your visual area and make a methodical sweep to the right, pausing in each block of viewing to focus your eyes. At the end of the scan, return to the panel.



#### Front-to-side scanning method.

Start at the center block of your visual field (center of front windshield); move to the left, focusing in each block then swing quickly back to the center block after reaching the last block on the left and repeat the performance to the right.

Figure 3.

sweep blurs the vision and will not identify targets in a timely manner.

There is no “one size fits all” technique for an optimum scan. Many pilots use some form of the “block” system scan (see figure 3). This method divides the sky into blocks, each spanning 10 to 15 degrees of the horizon, and 10 degrees above and below it. All the sky that generally needs to be monitored from the cockpit comprises nine to 12 blocks, or scan areas. The block scan is based on imagining a point in space at the center of each block. Focusing on each point allows the eye to detect a conflict within the foveal field, as well as contrasting or moving objects in the peripheral area between the center of each scanning block.

One common block scan technique is the “side to side” scan: Starting on one side of the aircraft, the pilot sweeps to the other side block by block. Another is the “front to side” scan: Starting with the block straight ahead, the pilot scans the blocks to one side of the aircraft, returns to the center, and repeats the process to the other side. Having a variety of scanning techniques available helps avoid the monotony of using one method all the time, which tends to result in diminished attention.

A scan covering 60 degrees on either side of the nose can detect the great majority of collision threats. But as previously discussed, MACs involving one aircraft overtaking another do occur. To counter this threat, check further behind, to the nine o’clock position and further aft, every few scans. This is particularly important during approach and landing when most such collisions occur. It’s important to scan vertically as well as horizontally. The area 10 degrees above and below your flight path contains virtually all potentially

conflicting traffic. Unless the target is climbing or descending rapidly, aircraft outside that range can be discounted as a threat.

#### The “Blossom Effect”

Motion is invaluable in drawing the eye’s attention. Yet two aircraft on a collision course will appear virtually motionless to each other, or maintain a constant relative bearing (CRB). When observed from the cockpit, the conflicting target will look like a small, stationary



Blossom Effect

speck until it is at a distance from which it may be too close to react to, when it suddenly appears to grow much larger, a phenomenon called the “blossom effect.” If a pilot sees an aircraft that remains in the same spot in the windshield (unless it is directly ahead and moving in the same direction), there is a high probability the two aircraft will collide unless one changes course. Once a threat has been identified, it’s essential to keep the other aircraft in sight until the threat is resolved. That may require turning toward the target to maintain visual contact.

#### CRM (Cockpit Resource Management)

Efficient scanning requires efficient management of other cockpit duties, particularly a good panel scan; the more quickly instruments and gauges can be



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monitored, the more time can be spent looking outside for conflicting traffic. An experimental scan training course conducted with military pilots found the average time needed to conduct the operations essential to flying the airplane was 20 seconds – 17 seconds for the outside scan, and three seconds for the panel scan. Without the benefit of intensive military training, most pilots will need more time than this. But as demonstrated by the military pilots, considerably more time should be spent on the external scan than the panel scan.

CRM also includes effective management of distractions such as passengers, avionics, and chart management tasks. Today's GPS receivers are extremely capable but they are also pilot workload intensive – particularly when multiple waypoints must be inserted into a flight plan. GPS receivers should always be programmed on the ground to provide more traffic scanning time in the air.



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## Phases of Flight

Midair collisions can and do happen in any phase of flight: takeoff, climb, climb-to-cruise, cruise, descent, maneuvering, approach, and landing. But the great majority occur in four phases: cruise, maneuvering, approach, and landing. Avoidance strategies need to be adjusted to reflect the risks and flight environment associated with each.

### Approach and Landing

About 45 percent of collisions occur in the traffic pattern and of these, 66 percent occur during approach and landing – when aircraft are on final or actually on or over the runway. These collisions typically have their genesis in the pattern. Given the small funnel of airspace planes occupy during landing, any confusion about who's landing in what order, and where they are, can have tragic consequences. If there is any consolation about collisions occurring during landing, it's that there are often survivors. Operations at nontowered airports present the greatest risk.

### Cruise

More than 20 percent of midair collisions occur during cruise, the en route portion of the flight, with altitude, power settings, and heading established. According to the NTSB, one common thread links the majority of these accidents: inattention on the part of the crews of both aircraft. In almost all cases, both crews were in a position to see the other aircraft in enough time to take evasive action, and action on the part of either of the crews would have avoided the collision. Without the distractions created by arrival and departure, cruise is the phase of flight when pilots have the most time to look for traffic. But it is also the longest phase of flight and the time of greatest complacency.

### Maneuvering

Collisions during maneuvering account for almost 20 percent of midairs. They can occur in the pattern or away from an airport. Two aircraft engaged in formation flying or in air-to-air photography commonly figure in accident reports. The best way to avoid such MACs is to seek specialized training before attempting any formation flight. Also, any formation flight must be carefully planned on the ground, so that the pilots of both aircraft are fully briefed, properly trained, and know exactly how the flight will be conducted. Safety pilots should be used whenever possible in such situations.



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MACs can also occur while maneuvering in the traffic pattern as a result of improper or misunderstood position reports, or erroneous assumptions. This is particularly true at nontowered airports. A pilot may conclude, for example, that no aircraft are in the pattern because of lack of activity on the frequency. But aircraft without radios may be operating at these airports, or an inbound or outbound aircraft may be transmitting on the wrong frequency.

In addition to looking for other traffic, remember the rules for right of way on final as defined by CFR Part 91.113 (g): "When two or more aircraft are approaching an airport for the purpose of landing, the aircraft at the lower altitude has the right-of-way, but it shall not take advantage of this rule to cut in front of another which is on final approach to land or to overtake that aircraft."

For a detailed discussion of nontowered airports see  
Operations at Nontowered Airports  
[www.aopa.org/asf/publications/sa08.pdf](http://www.aopa.org/asf/publications/sa08.pdf)

## Avoidance Strategies

### Altitudes

Flying at proper cruising altitudes can reduce the risk of MACs and help pilots focus their scans in areas where threats are most likely to appear. For VFR flights at 3,000 feet agl and above, the correct cruising altitudes are odd thousands plus 500 feet on courses of zero degrees through 179 degrees, and even thousands plus 500 feet for courses of 180 degrees through 359 degrees. This rule can help pilots develop a scanning strategy for any given flight.

If an aircraft is southbound on a heading of 180 degrees or greater – that is, at an even plus 500-foot cruising altitude – almost all conflicting traffic will come from the left. VFR aircraft coming from the right will be on courses that mandate odd plus 500-foot altitudes, providing at least 1,000 feet vertical separation from them (unless, of course, the pilot is flying at the minimum VFR cruising altitude). Conversely, if the course is just east of a due south heading, calling for an odd plus 500-foot altitude, almost any conflicting aircraft should come from the right. When northbound on courses calling for odd altitudes, most threats will come from the left; while northbound on even altitude courses, most will come from the right. East- or westbound pilots need to be more concerned about traffic converging from the side or from behind; VFR targets coming from the opposite direction should be at least 1,000 feet above or below.

This strategy doesn't preclude the need to scan in areas where threats are less likely, since planes descend and climb, and not all pilots fly according to regulations. But it can help deploy limited cockpit resources where they're most needed.

When cruising at altitudes where no en route cruising level is mandated (i.e., 3,000 feet agl (above ground level) and below), avoid flying at 1,000-foot or 1,000 plus 500-foot altitudes (e.g., 1,500 feet, 2,000 feet, 2,500 feet). These tend to be more crowded than other available altitudes below 3,000 feet.

### Congested Airspace

Plan flights to avoid crowded skies. Don't overfly VORs. Even in the GPS era of point-to-point navigation, nav aids can draw a crowd. If they are on your route, fly to the

right of course and maintain special vigilance in the vicinity. Avoid overflying approach fixes or holding points that may attract aircraft. Stay clear of military training routes, the fringes of controlled airspace, and other high traffic areas when possible. When getting a briefing, find out which special use airspace along your route is active. When crossing military training routes, fly across them at a perpendicular angle to minimize the time spent in the area. If you see a military fighter, look for the wingman – they usually travel in pairs.

A collision between a Cessna 172 and an Air Force F-16 near Sarasota, Florida, illustrates the hazards associated with flying near military training routes (MTRs). The MTR program is a joint venture by the FAA and the Department of Defense (DOD). Generally, MTRs are established below 10,000 feet msl for operations at speeds in excess of 250 knots. However, route segments may be defined at higher altitudes to accommodate descent, climbout, and mountainous terrain.

Routes above 1,500 feet agl are usually flown under instrument flight rules (IFR) and are designated with the letters IR and a route identification number. MTRs at 1,500 feet agl and below are usually flown under VFR. They are designated with the letters VR and a route identification number. IRs and VRs with no route segments above 1,500 agl have a four-digit number, e.g., VR1007. Routes above 1,500 feet agl have a three-digit number, e.g. IR008.

Some MTRs alternate between IR and VR, e.g., VR008A,IR1007B. Only the centerline of MTRs is depicted on sectional charts. In some cases the routes may be 20 miles wide. Pilots should be on the lookout for fast moving military aircraft whenever flying near charted MTRs. If you see one airplane, keep on



If you see a military fighter, look for the wingman—they usually travel in pairs.

scanning - fighters usually travel in pairs. Because MTRs are subject to change every 56 days, users of VFR charts are advised to contact Flight Service for route dimensions and current status of those routes affecting their flight. VFR flight following or IFR is recommended, where possible, to increase coordination and collision avoidance service. Remember, however, in VFR conditions the pilot has primary responsibility for collision avoidance.

### Lighting

Exterior lights can make your aircraft more visible to others, even during daylight hours. Recognition lights can increase an aircraft's visibility by a factor of 10. Strobe lights also increase conspicuity. Consider installing recognition lights if your aircraft isn't equipped with them. Use your landing light on approach and departure, even during daylight hours. At night, when ATC alerts you to traffic ahead or when you see oncoming traffic, turn on your landing light. This will help the traffic to see you. Turning on your landing light on your initial call to a tower can help controllers to see and identify your aircraft.

### Sterile Cockpit

Complacency and lack of attention are the enemies of MAC avoidance strategies. To keep crews focused on the business of flying, most airlines mandate a "sterile cockpit" at altitudes below 10,000 feet agl; that is, all conversation not pertaining to operation of the aircraft is forbidden during these times. Maintaining this altitude standard may not be practical for most GA pilots, who often don't fly as high as 10,000 feet agl, but the sterile cockpit concept is. Don't engage in idle conversation during the first and last 10 minutes of a flight, for example, or within 20 miles of the airports or navigation facilities. Concentrate instead on scanning for conflicting traffic and other operational concerns.

### Flight Following

Flight following, or obtaining radar advisories from ATC, is another useful collision avoidance tool. It gives pilots another set of eyes to watch for traffic: those of an ATC controller who monitors radar returns and advises them of potential traffic conflicts. However, though ATC may provide traffic advisories when in radar contact, these advisories are provided on a time-permitting basis. Separation from other aircraft remains the responsibility of the pilot in command.

# The FAA attributes a significant percentage of incursions to general aviation pilots who mistakenly taxi onto an active runway.

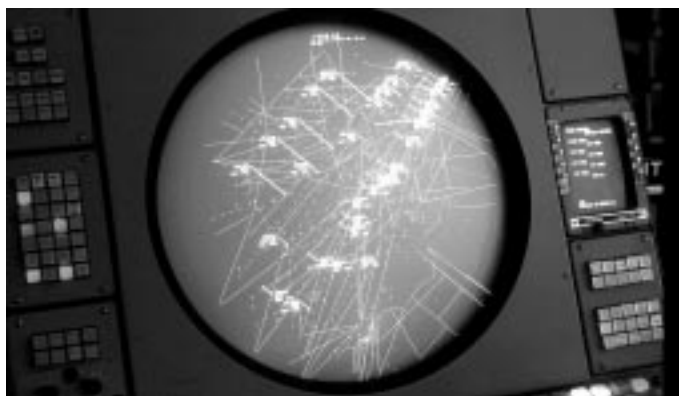
If an aircraft doesn't have a transponder – or doesn't have it turned on – it paints a much weaker image on the radar screen. That can make it difficult for the controller to see and warn other aircraft should the transponder-less aircraft pose a threat.

This may have been a contributing factor in a 1998 midair collision involving a Cessna 172 and a Cessna Citation inside Atlanta's Class Bravo mode C veil. After the accident, the transponder in the C-172, whose pilot was not in contact with the approach facility, was found in the off position. No traffic advisory was issued to the jet. Though on an IFR flight plan, the Citation was in VFR conditions, and it was the responsibility of the PIC to see and avoid other aircraft.

**Note:** Even if you're not receiving advisories, monitoring ATC and Common Traffic Advisory Frequency (CTAF) can give you valuable information about traffic near you.

## Nontowered Airports

As stated earlier, the majority of midair collisions occur



Flight following is recommended when flying VFR.



Most MACs occur at nontowered airports.

within five miles of an airport. Most of these occur in the approach and landing phase at nontowered airports. Because no one is organizing the airplanes in the pattern or coordinating landing traffic at these facilities, operating in and out of nontowered airports requires special diligence. Use these procedures to reduce the risks:

- Have radio frequencies verified and ready before you enter the airport traffic area.
- If working approach control while inbound to a nontowered airport, monitor the CTAF frequency on your second radio.
- Report your position 10 miles out and listen to position reports from other inbound pilots; report entering the pattern, turning downwind to base, and base to final.
- Identify the airport at the beginning and end of each transmission.
- If you're unsure about the position of an aircraft on the frequency, ask its location.
- Remember that airplanes with no radios can be operating at nontowered airports.
- Slow down! Speed reduces reaction time. Collisions on approach typically involve a faster aircraft overtaking a slower one.
- Check behind and below you for conflicting traffic at least once on final.
- Report your position outbound, and be aware that most outbound pilots don't give position reports after departure.
- If on approach on an IFR flight, report position by distance in miles rather than approach fixes.



Situational awareness is critical on the ground as well as in the air.

## Runway Incursions

Collisions on the ground can be every bit as deadly as those in the air. History's greatest aviation disaster involved two B-747s that collided on the ground in the Canary Islands in 1977, claiming the lives of 582 people. The major danger comes from runway incursions, defined as any occurrence at an airport involving an aircraft, vehicle, person, or object on the ground that creates a collision hazard or results in loss of separation with an aircraft taking off or intending to take off, landing or intending to land. Between 1993 and 1999, reported runway incursions, or surface deviations, rose 71 percent. Incursions per 100,000 flight operations increased 56 percent during the same period. The FAA attributes a significant percentage of incursions to general aviation pilots who mistakenly taxi onto an active runway.

Situational awareness, so important in the air, is also critical in avoiding surface deviations. Miscommunication, inattention, and lack of information lie at the root of incursions. Pilots may misunderstand taxi instructions, and controllers have been known to misunderstand an aircraft's position on the field. A pilot may be preoccupied and not notice passing a position at which he was told to hold, such as before crossing a runway hold line. Or the pilot may not know where he is due to unfamiliarity with the field.

Typically, incursions by GA aircraft result in go-arounds or reduced separation between conflicting traffic rather than accidents. But these incursions can also have catastrophic results, whether they occur at controlled or nontowered airports, as recent accidents prove. In Sarasota, Florida, a C-172 and

Always review the layouts of destination and en route airports during your flight planning. Charts can be just as important for navigating across an airport as through the airspace overhead.

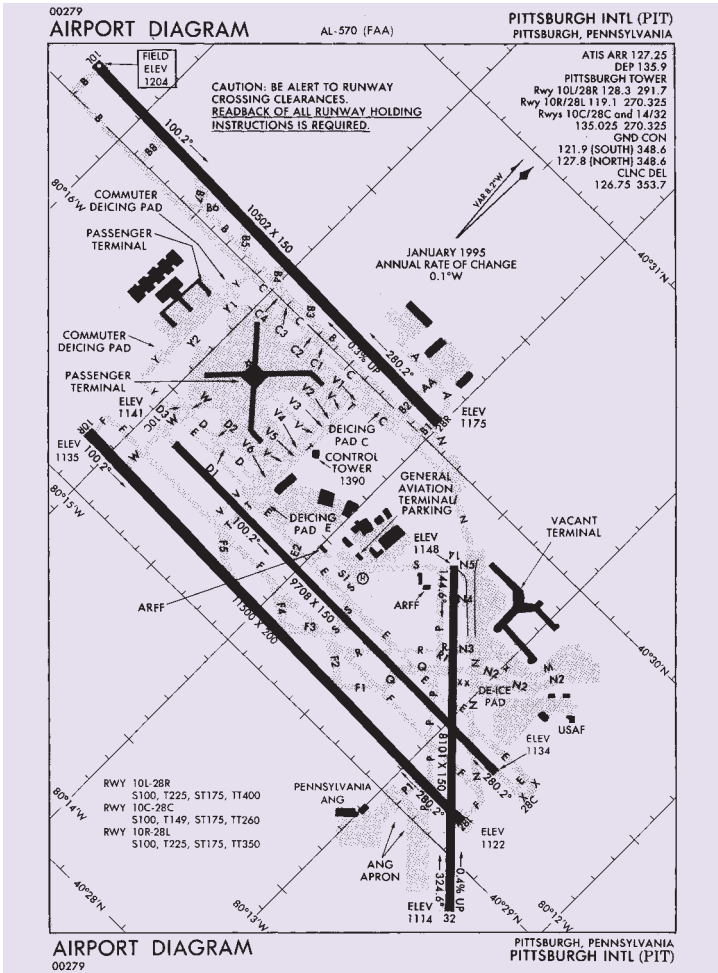
C-152 collided on the runway at the controlled airport, resulting in four fatalities. According to preliminary reports by the NTSB, confusion in the tower and lack of attention in the cockpit were factors in the accident. The C-152 had been cleared for takeoff. The C-172, which was holding short for an intersection departure, was then cleared onto the runway, and taxied right into the path of the C-152 on its takeoff roll. The controller thought the C-172 he'd cleared onto the active was the aircraft waiting behind the C-152. And those aboard the C-172 involved in the accident apparently didn't look for traffic before proceeding onto the active runway. This accident underscores the fact that pilots need to maintain constant vigilance, whether under the control of ATC personnel or not. Announce your position to controllers, particularly when making intersection departures. Always look for conflicting traffic before taxiing onto or across any runway. And remember, your N number may not be visible to controllers, even with binoculars.

The collision of Beech King Air A90 and a Beech 1900 airliner at Quincy, Illinois, illustrates the potential consequences of incursions at nontowered airports.

CVR (Cockpit Voice Recorder) tapes from the B-1900 indicate that confusion and lack of attention and communication played prominent roles in this disaster. The B-1900 was on a straight in approach for Runway 13, and announced its intentions on the CTAF. The King Air announced it was going to take off on Runway 4. The crew of the B-1900 asked if the King Air was going to hold until they landed. However, a third aircraft at the airport, a Cherokee behind the King Air on Runway 4, responded that he would hold, and that transmission was partially blocked, apparently leading the 1900 crew to believe the transmission was from the King Air. The B-1900 continued with its landing as the King Air commenced its takeoff roll. They collided at the intersection of the two runways, claiming the lives of all those aboard both aircraft.

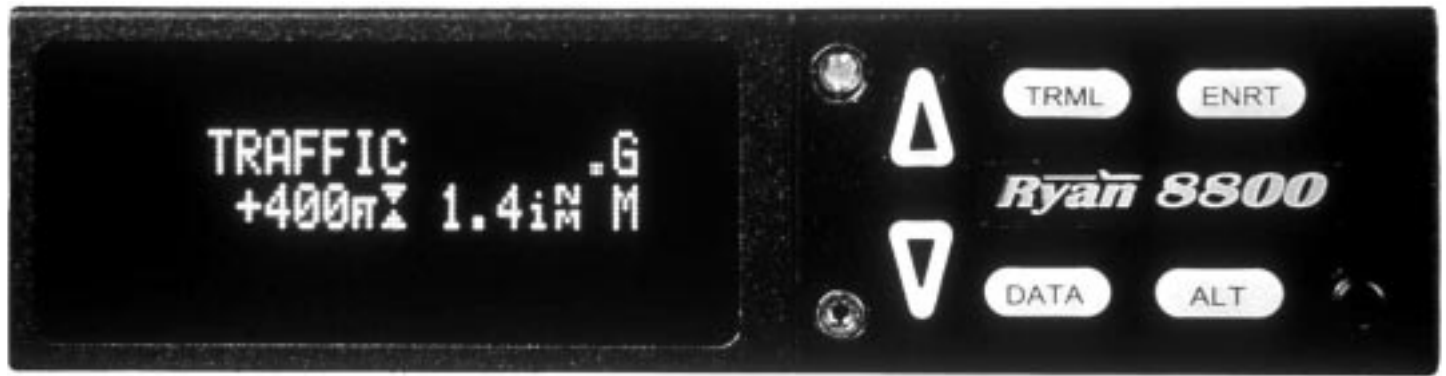
To learn more about runway incursion avoidance, view the ASF's interactive Runway Safety Program online at [www.aopa.org/asf/runway\\_safety/](http://www.aopa.org/asf/runway_safety/)

Always review the layouts of destination and en route airports during your flight planning. Charts can be just as important for navigating across an airport as through the airspace overhead. AOPA's Air Safety Foundation has airport diagrams on our Web site for many of the nation's busiest airports, and they can be easily downloaded and printed out by anyone with a computer and Internet connection ([www.aopa.org/asf/taxi](http://www.aopa.org/asf/taxi)). Pay attention while taxiing – don't use the time to program the GPS or dig for charts. And make sure you understand all instructions.



## Avoiding Runway Incursions –

- Before taxi prior to departure and en route prior to landing review the anticipated taxi route.
- Listen carefully to instructions. The route you're given may not be the one you expected.
- Read back all ground and tower taxi instructions.
- Confirm permission to cross any and all runways prior to crossing them.
- Acquire airport diagrams for unfamiliar airports.
- If in doubt, ask for progressive taxi instructions at unfamiliar airports.
- Look for traffic before taking the runway. Assure no conflicting ground traffic before beginning the takeoff.
- At nontowered airports with intersecting runways, check for traffic on the crossing runway as well as the one you intend to use for departure; do the same when landing at these airports.
- At airports with parallel runways, be aware of the potential for confusion created by the "left" and "right" runway designations.
- Be familiar with all relevant taxiway and runway signage.



Ryan TCAD (Traffic Collision Avoidance Device).

## Collision Avoidance Technology

Technology in the cockpit is now helping pilots to see and avoid other aircraft. All air carrier aircraft are equipped with TCAS, or Traffic Alert and Collision Avoidance Systems. There are two versions: TCAS I and TCAS II.

TCAS I indicates the bearing and relative altitude of all aircraft within a selected range, generally 10 to 20 miles. With color-coded symbols, the display indicates which of the aircraft pose a potential threat. TCAS I does not offer solutions, that is, what evasive action to take, but it supplies pilots with important data so that they can determine the best course of action.

TCAS II, in addition to a traffic display, provides pilots with resolution advisories, or RAs, when needed. The system determines the course of each aircraft and whether it is climbing, descending, or flying straight and level. TCAS II then issues an RA advising the pilots to execute the type of evasive maneuver necessary to avoid the other aircraft, such as "Climb" or "Descend." If both planes are equipped with TCAS II, then the two computers offer deconflicting RAs, assuring pilots' actions end, rather than exacerbate, a collision threat.

General aviation pilots have access to similar equipment now. The Ryan TCAD, or Traffic Collision Avoidance Device, works much the same way as TCAS systems, by picking up and processing the transponder signals from nearby traffic, and figuring which ones present a potential collision threat. Once a threat is identified, the TCAD displays the distance, bearing, and vertical separation above or below, and whether the target is climbing, descending, or in level flight. Low-cost portable units that can pick up transponder signals and issue conflict alerts are also appearing on the market, bringing collision avoidance technology down to prices that a much greater percentage of the pilot population can afford.

ADS-B, Automatic Dependent Surveillance Broadcast, represents a next generation collision avoidance technology. Designed to accommodate the "free flight" concept, an ADS-B equipped aircraft broadcasts a signal that contains a GPS-derived location. The signal, rebroadcast by ground station or satellite, can be displayed in other ADS-B equipped aircraft, giving pilots critical collision avoidance information without input from ground-based controllers. This same technology also allows displays of real-time weather and text messaging. A low-cost technology, the FAA is currently funding a three-year test of ADS-B in Alaska.

# Collision Avoidance Checklist

You now have the knowledge to minimize the threat of collisions in the air and on the ground. Keep the following tactics in mind before every flight.

## ✓ Plan your flight

Know your route, the frequencies you'll need along the way, and the airport you'll be arriving at. Fold charts and preset navigational aids to maximize scan time. Program GPS – nav computers on the ground to minimize heads down time in the air. Consider where high traffic/high workload areas will be. Avoid them if possible or plan on being extra vigilant during those phases of the flight.

## ✓ Clean your windshield

A squashed bug on the glass can block an aircraft from view and make it more difficult to focus properly. Make S turns for improved forward visibility during the climb. Climbing at cruise airspeeds accords a better view over the nose.



## ✓ Enlist passengers

As part of your preflight briefing, explain basic scanning procedures to passengers and have them assist in looking for traffic. Explain FAA radar advisory procedures, so they can help locate traffic called by ATC.

## ✓ Use aircraft lights

Install and use anticollision lighting so that if you don't see a potential threat, maybe the threat will see you. Strobe lights can improve an aircraft's ability to be seen day or night. Use your landing light on approach, departure, and climbout.

## ✓ Use sunglasses

Sunglasses that block out UV rays help protect your vision and reduce eye fatigue. Red/yellow spectrum lenses make it easier to see through haze. Polarized lenses reduce glare, but this may be a detriment to spotting traffic as the glint of light bouncing off an aircraft may help make it visible.



## ✓ Observe proper procedures

Use correct cruising altitudes and traffic patterns. Announce your position at nontowered airports. Recognize that not everyone follows the rules.

## ✓ Communicate

At airports with radar approach control, contact the facilities at the distances prescribed on aeronautical charts. At nontowered airports, announce your position starting 10 miles out.



## ✓ Become a target

If you operate an aircraft without radios or transponders, consider installing them. Regulations require that aircraft equipped with transponders must squawk mode C while in flight.

## ✓ Scan for traffic!

Use the techniques presented. Adapt them to your needs. Use your eyes and your head together (see scan diagram on page 6).



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